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IX.—*Notes on the Palæozoic Corals of the State of Ohio.*

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[Plate V.]

IN the spring of the year 1874 I was asked by Professor Newberry, the accomplished head of the Geological Survey of Ohio, to undertake the description of the Corals which had been obtained by the officers of the Survey within the limits of the State. At this time I was on the point of leaving America for England; a large part of my private library was already packed up; and the only public library to which I could refer was very imperfectly supplied with works dealing with the Palæozoic corals. I had, further, neither the time nor the means for making the necessary microscopic sections of the specimens submitted to me. Under these circumstances, it was inevitable that errors would be committed to some extent. Since my return to England, my collections remained for long packed up; and I had no opportunity of revising the proofs, or of rectifying these errors, before the second volume of the 'Palæontology of Ohio' went to press. I have, however, during the last winter unpacked my collections of American corals, and have sliced a large number of them for microscopic examination. I wish, therefore, now to correct such mistakes as were made in my original Report, and to add certain details which were there omitted. On the present occasion I shall confine my remarks to certain of the species of *Chetetes*, *Constellaria*, and *Streptelasma*.

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Chatetes rhombicus, Nicholson, Geological Survey of Ohio, Palæontology, vol. ii. p. 201, pl. 21. figs. 12, 12 a.

Microscopic sections of this beautiful species prove its distinctness from all other previously described members of the group in the most conclusive manner. In cross sections (Pl. V. fig. 1) the central portion of the corallum is seen to be occupied by the transversely divided ascending corallites of this region. Each tube is rhomboidal or diamond-shaped; and the corallites are arranged, with geometrical regularity, in a double series of decussating gently curved diagonals. The tubes are filled with transparent calcite; and each has its rhomboidal area very distinctly and regularly divided into four equal triangles by a cruciform divisional line. These divisional lines in the interior of the tubes are perfectly regular in their arrangement, and are quite uniform in their direction in each specimen (Pl. V. fig. 1 a); they therefore give rise to a second, fainter, double series of diagonal lines, which intersect the more strongly marked series of diagonals formed by the walls of the tubes themselves. Similar, but less conspicuous and less regular, divisional lines are visible in the calcite which fills the tubes of the corallites in many species of *Chatetes* and in *Constellaria*; but I have been unable to satisfy myself as to the true cause of this phenomenon. In longitudinal sections (Pl. V. fig. 1 b) the corallites are seen to be nearly vertical in the central portion of the ramose corallum, and to curve outwards at a considerable angle as they approach the surface. It is owing to this arrangement of the tubes that the central portion of a cross section (Pl. V. fig. 1) shows the corallites divided transversely; at right angles to their direction, whilst the marginal portion of a cross section shows the tubes cut obliquely but in the main longitudinally. In the central and vertical portion of their course the corallites are destitute of tabulæ; but these structures are well developed in the outer (more nearly horizontal) portion of the tubes. The corallites increase somewhat in diameter in approaching the surface; and interstitial tubuli are wholly wanting.

The increase of the corallum is clearly shown by longitudinal sections to take place by fission of the old corallites, and not by gemmation. The species must therefore be placed in the genus *Chatetes*, and not in *Monticulipora* as ordinarily understood. In fact, so far as my present investigations have gone, all the species ordinarily referred to *Monticulipora* can be shown, by properly prepared sections, to increase by fission of the old tubes; and they must therefore be placed in *Chatetes*,

unless some distinction other than the mode of growth can be shown to separate these two groups.

Chaetetes sigillarioides, Nicholson, *op. cit.* p. 203, pl. 22.
figs. 9, 9 a.

I have at present only examined longitudinal sections of this species, which, however, are highly characteristic. In the central portion of the corallum (Pl. V. fig. 2), the corallites are nearly vertical, with slightly flexuous walls, and wholly destitute of tabulæ. As they ascend from the centre towards the surface the corallites become curved outwards, and a few remote tabulæ become developed in them, though these structures are always scanty and may be entirely absent. Between the proper corallites, in the outer portion of their course, are developed minute interstitial tubuli, which are furnished with close-set and regular tabulæ. The plate which I have described as filling up so many of the calices in this form, and which may probably be regarded as a species of operculum, is not visible in sections.

Chaetetes nodulosus, Nicholson, *op. cit.* p. 200, pl. 21.
figs. 10, 10 a.

The longitudinal sections of this species (Pl. V. fig. 3) agree with those of the preceding species in many points. The corallites, however, in the ascending portion of their course are furnished with remote but regular tabulæ throughout, as they are near the surface also; the interstitial tubuli which are present, though closely tabulate as in *C. sigillarioides*, are much less regular and frequent than in the latter species; and the outline of the surface is broken by projecting "monticules." The external characters of these two species are still more decisively different.

Chaetetes rugosus, Edwards & Haime.

Chaetetes rugosus, Nich. *op. cit.* p. 193, pl. 21. fig. 2.

Longitudinal sections of this species, as of the preceding, show that the corallites in the central portion of the corallum are nearly vertical, and that they gradually curve outwards in approaching the surface (Pl. V. fig. 4). Some of the corallites are of considerable size, and appear to be free from tabulæ; others, rather smaller as a rule, are provided with regular transverse tabulæ; and, lastly, there are a number of minute interstitial tubuli, in which the tabulæ are very numerous and closely set.

Chaetetes ramosus, Edwards & Haime.*Chaetetes Dalei*, Nich. op. cit. p. 192, pl. 21. figs. 1, 1 a.

The form which I described as *C. Dalei*, E. & H., seems to be really the *C. ramosus* of these authors. Its internal structure, as shown by sections, is quite identical with that of *C. rugosus*, E. & H.; and it would seem to be probable that these two forms are no more than strongly marked varieties of a single species, whilst the true *C. Dalei*, E. & H., may be nothing more than a smooth variety of the same form.

Chaetetes petropolitanus, Pander.*Chaetetes petropolitanus*, Nich. op. cit. p. 204, pl. 21. figs. 14, 14 a.

I have made sections of a considerable number of examples of this variable form from the Trenton Limestone of Canada, the Cincinnati Group of Ohio, and the Lower Silurian rocks of Sweden; but I have not as yet had the opportunity of examining Russian specimens. So far as I have seen, the internal structure of this species is very constant and characteristic, however widely different specimens may differ in external aspect and mode of growth. In longitudinal sections (Pl. V. fig. 6) the tubes are seen to differ considerably in size, and they may be considered as belonging to three groups. The largest tubes exhibit a peculiar phenomenon, which occurs in some other species of *Chaetetes* as well. Each tube, namely, is divided down its centre into two compartments by an irregular, flexuous, and delicate vertical septum. On the one side of this septum the tabulæ are usually curved, with their convexities directed outwards, and are tolerably numerous, and often more or less oblique; whilst on the other side the tabulæ are more remote, and are directed at right angles across the corallites. The tubes of the second group are smaller than the preceding, and are furnished with regular transverse tabulæ. Lastly, there is a group of small tubuli, irregularly interspersed at short intervals amongst the larger tubes, in which the tabulæ are very numerous and very closely set. In transverse sections (Pl. V. fig. 6 a) the corallites are seen to be more or less polygonal in outline, usually hexagonal or pentagonal, with very thin walls. No interstitial tubuli are to be observed, though these would doubtless be visible in a section cut tangential to and near the external surface.

Chaetetes discoideus, James.*Chaetetes discoideus*, Nich. op. cit. p. 206, pl. 21. figs. 15-15 c.

This species forms thin, flattened, concavo-convex disks,

which might readily be taken for young forms of *C. petropolitanus*. The characters shown by sections would appear, however, to render this hypothesis untenable, or, at any rate, unlikely. As seen in transverse sections (Pl. V. fig. 7), the corallites are irregularly polygonal or rounded, with thick walls, and having numerous small tubes scattered amongst those of the ordinary size. In vertical sections (Pl. V. fig. 7a), the corallites are seen to be directed upwards from the basal concave epitheca, with a slight oblique curvature. Their walls, at first thin, become thickened in approaching the surface; and their interior is crossed by delicate and comparatively remote tabulæ. Small tubuli are occasionally interspersed amongst those of the usual dimensions; and these are more closely tabulate than is the case with the full-sized corallites. It will thus be seen that, both in horizontal and vertical section, *C. discoideus* differs greatly from adult examples of *C. petropolitanus*.

Chætetes Newberryi, Nicholson, *op. cit.* p. 212, pl. 22.
figs. 4, 4a.

In external form this species is superficially very like *C. discoideus*, James; but its more minute external characters are very different, and these differences are fully borne out by an examination of the internal structure of both forms. The corallites appear, in transverse sections (Pl. V. fig. 8), as approximately circular tubes of nearly equal size, and arranged in regular rows, those of contiguous rows being sometimes placed opposite each other, sometimes alternately. The walls of the corallites are thick; and at every point where four corallites come together is placed a small circular tube. Every corallite, therefore, is surrounded by four of these smaller tubuli. In vertical section (Pl. V. fig. 8a), the corallites are directed upwards with a slight curvature from the attached base, each being furnished with a few regular and remote tabulæ. Interspersed with the ordinary corallites are minute tubuli, with numerous close-set tabulæ. In this latter feature, this species, as is the case with several other species of *Chætetes* (*Monticulipora*), reminds one forcibly of the *Heliolitidæ*.

Chætetes Jamesi, Nicholson, *op. cit.* p. 200, pl. 21.
figs. 11, 11a.

The internal structure of this fine species is very characteristic. In the centre of the corallum, as seen in vertical

sections of the branches (Pl. V. fig. 5), the corallites are vertical, diverging slightly outwards towards their summits, and then turning abruptly, and nearly at right angles, to reach the surface. In the vertical portion of their course the corallites have thin undulating walls, and are destitute of tabulæ. In the outer horizontal portion of their course the corallites have thicker walls, are provided with delicate remote tabulæ, and are interspersed with smaller tubes furnished with numerous close-set tabulæ. The increase of the tubes is by fission. Though more closely allied in its general features to *C. tumidus*, Phill., than to any other species of the genus, *C. Jamesi* is shown by microscopic sections to be perfectly distinct. The former species is distinguished by the fact that the corallites do not turn at right angles to gain the surface, but curve gradually outwards, by the presence of remote tabulæ in the central corallites and the almost total absence of tabulæ in the corallites in the external portion of their course, and, lastly, by the fact that the numerous interstitial tubuli do not seem to be provided with tabulæ.

Chaetetes gracilis, James.

Chaetetes gracilis, Nich. op. cit. p. 198, pl. 21. figs. 8, 8 b.

The internal structure of this species is likewise very distinct and characteristic. In long sections (Pl. V. fig. 13) the tubes in the central portion of the branches are seen to be nearly vertical, slightly undulating, with thin walls, and crossed here and there by an occasional tabula. As they approach the surface the corallites bend gently outwards, becoming much more strongly undulated, with thickened walls, and increasing in number rapidly by fission. In the outer portion of their course the larger corallites are furnished with a few remote tabulæ, whilst the smaller corallites have a considerable number of these structures. In tangential sections, taken close to the surface, the corallites are seen to be oval or rounded, with extremely thick walls, and having a number of very minute, circular, interstitial tubuli interspersed amongst them. This form is at once distinguished from *Chaetetes* (*Monticulipora*) *Fletcheri*, E. & H., amongst other characters, by the thick-walled strongly undulated corallites.

Chaetetes Fletcheri, Edwards & Haime.

Chaetetes Fletcheri, Nich. op. cit. p. 197, pl. 21. figs. 7, 7 a.

Though very like *C. gracilis*, James, in external characters and general appearance, *C. Fletcheri* is distinguished from that

species, in long sections, by the wide straight corallites, which are furnished with regular remote tabulæ, and which have small, more closely tabulate tubuli occasionally intercalated amongst them. In cross sections (Pl. V. fig. 14) the corallites are seen cut longitudinally around the margin and transversely divided in the centre, where they are polygonal and thin-walled.

Chaetetes tuberculatus, Edwards & Haime.

Chaetetes corticans, Nich. *op. cit.* p. 210, pl. 22. figs. 6, 6 a.

There can be no doubt that the form to which I gave the name of *C. corticans* is really identical with the *C. tuberculatus* of Edwards and Haime. I have not yet had the opportunity of making sections of this species, and am therefore unable to give any details as to its internal structure.

Chaetetes clathratulus, James.

Chaetetes clathratulus, Nich. *op. cit.* p. 209, pl. 22. figs. 2, 2 b.

It seems not unlikely that this is really the *Chaetetes* (*Ptilodictya*) *pavonia* of D'Orbigny; but the published figures of the latter species do not allow of a satisfactory determination of this point. Be this as it may, the internal structure of *C. clathratulus* is highly characteristic and peculiar. In tangential sections taken parallel with the surface (Pl. V. fig. 9), the corallites are seen in the form of oval tubes, arranged in two series of regularly decussating diagonals, each tube being directed with its long axis oblique to the row to which it belongs. The walls of the corallites are very thick, and no interstitial tubuli are present. Each corallite seems to be primitively more or less hexagonal or diamond-shaped; and the oval section of the interior of the tube is clearly due to a secondary thickening of the walls. In long section (Pl. V. fig. 9 a) the corallum is seen to consist of two strata of corallites directed outwards in opposite directions from a delicate, flexuous, median lamina, with which their walls are sometimes connected by thin plates. Sometimes (as in the figure) a second stratum of short corallites may be superimposed upon one of the original layers. The walls of the corallites are very thick; and tabulæ appear to be wholly absent. This latter feature leaves it still doubtful if this singular form can really be referred to *Chaetetes*.

Chaetetes frondosus, D'Orbigny.

Chaetetes frondosus?, Nich. *op. cit.* p. 208, pl. 22. figs. 1, 1 b.

I am still in doubt whether my specimens are really refer-

able to *C. frondosus*, D'Orbigny, or whether two superficially similar forms have not been included under this name. Sections of my specimens taken parallel with the surface (Pl. V. fig. 11) show very striking features. The majority of the corallites are oval or rounded, and have very thick walls. In the spaces between the ordinary corallites are placed smaller oval or rhomboidal tubes, of the same character as the preceding; and, lastly, there is a great number of very minute, circular, interstitial tubuli, the walls of which are so dense as to look black in sections. These smallest tubuli are irregularly scattered amongst the larger ones, and very often are so placed as to project into the cavity of one of the large corallites. In long sections (Pl. V. fig. 9 a), the corallum is seen to consist of two strata of corallites, which are directed outwards at right angles and in opposite directions from a thin undulating median lamina, with which they are connected by delicate curved tabulæ. Three kinds of corallites are present, as in *C. petropolitanus*. In one kind, the largest of all, the interior of the tube is divided into two halves by a delicate wavy vertical septum; in one half of the tube the tabulæ are more or less curved, and in the other half they are generally straight and less numerous. In another kind, rather smaller than the preceding, the tubes are simply crossed by straight, comparatively remote tabulæ. Lastly, there are numerous minute tubuli, in which the tabulæ are very closely set.

Constellaria antheloidea, Hall.

Constellaria antheloidea, Nich. op. cit. p. 214.

In its internal structure this genus very closely approaches *Chatetes* (*Monticulipora*); and it is doubtful if the marked external peculiarities which it presents are sufficient to justify generic distinction. Vertical sections, taken through the centre (Pl. V. fig. 10 a), show that the corallites are nearly vertical in the middle of the corallum, and are divided by regular but very remote tabulæ. In approaching the surface the corallites bend outwards, and divide by fission into a number of more slender tubes, which are generally traversed by very numerous and close-set tabulæ. In cross sections (Pl. V. fig. 10) the corallites are seen on the circumference of the section to be cut longitudinally, as they bend outwards, and they are here finely tabulate, whilst a few of the larger tubes appear to be destitute of tabulæ. In the centre of the section the corallites are divided transversely, and they are here thin-walled and polygonal. The calcite filling the tubes is divided

by faint but quite regular cruciform lines, as in *C. rhombicus* and several other forms. In sections taken parallel with and close to the surface, the "monticules" are seen as so many stellate spaces, occupied by an irregular network of more or less angular and elongated cells, apparently representing sections of tubes obliquely proceeding towards the surface. The corallites appear as oval or circular tubes, which fill up the spaces not occupied by the monticules, and which are either in contact or, more commonly, are separated by a similar but closer angular network. No traces of minute, interstitial tubuli can be detected in sections of this kind.

Dekayia attrita, Nicholson.

Chaetetes attritus, Nich. *op. cit.* p. 194, pl. 21. fig. 4.

This form properly belongs to the genus *Dekayia*, and may perhaps be nothing more than a slender variety of *D. aspera*, E. & H. I originally was inclined to believe that the genus *Dekayia* was wholly inseparable from *Chaetetes*; but thin sections show characters which possibly may suffice for generic separation, though there is in most respects the closest relationship between the two groups. The little columnar eminences which stud the surface of *Dekayia*, and which alone distinguish the genus from *Chaetetes*, are not, as I imagined, simply of the nature of "monticules," but they are just as conspicuous in sections as they are superficially. In cross sections (Pl. V. fig. 12) the ordinary corallites are seen to be more or less polygonal, with thin walls, and destitute of interstitial tubuli. The larger corallites are arranged in radiating groups, of five or six each, the centre of each group being formed by one of the surface-columns. As seen in sections of this kind, the columns are somewhat polygonal, and are seen to be distinctly hollow. As seen in long sections (Pl. V. fig. 12 *a*), the corallites in the centre of the colony are vertical, with thin undulating walls, and destitute of tabulae. As they approach the surface the corallites curve outwards, and a few remote tabulae are developed in them. No interstitial tubuli are present. At intervals the walls of the corallites exhibit fusiform thickenings, which become more abundant as the surface is approached, and which represent the surface-columns cut in long section. As seen in sections of this kind, the columns are also clearly hollow; but their true nature is quite uncertain, and it is doubtful if, of themselves, they are sufficient to separate the genus from *Chaetetes* proper.

Streptelasma corniculum, Hall.*Streptelasma corniculum*, Nich. op. cit. p. 218.

Having now made carefully prepared thin sections of typical examples of this the type species of the genus *Streptelasma*, I am enabled to give the characters of the genus in greater detail, and to correct one or two errors in my former description. The corallum is free, simple, and turbinate, with a thick wall and a well-developed epitheca. The septa (Pl. V. fig. 15) are well developed, of two kinds. The majority of the primary septa fall short of the centre of the visceral chamber; but a certain number are continued inwards, in the form of irregular, tortuous, vertical plates, which often unite with one another, and give rise to a sort of subvesicular axis, which forms a low prominence in the bottom of the calice. Cross sections also show a well-marked septal fossula, including two or three short septa. The secondary septa are short, and alternate regularly with the longer ones. Dissepiments are not absent (as erroneously believed), but are developed to a small extent in a zone between the inner ends of the secondary septa and the central space, into which most of the primary septa do not enter. Some specimens exhibit hardly any dissepiments; others have a considerable number. In long sections (Pl. V. fig. 15 a) the visceral chamber is seen to be traversed by well developed tabulæ, which are convex upwards, are elevated centrally, and are somewhat, but loosely, vesicular towards the margin. In sections taken accurately across the centre, there are seen in the median line of the corallum a few vertical, sometimes more or less bent or twisted lamellæ. These are the edges of the tortuous central plates formed by the inward prolongation to the centre of a few of the primary septa. In the transverse section of *S. corniculum*, Hall, which I have here figured, there are fifty-seven primary septa and an equal number of secondary septa, and three of the primary septa are shorter than the others and stand in the septal fossula.

The genus *Streptelasma*, as founded upon the type species *S. corniculum*, can be certainly asserted to be a Rugose coral, and to be nearly allied to *Zaphrentis*. It differs from *Zaphrentis* in the smaller development of the tabulæ, in the fact that the fossula is not formed by the coalescence of a certain number of the septa, and in the prolongation to the centre of some of the primary septa as so many twisted plates.

EXPLANATION OF PLATE V.

[All the figures of this plate, except figs. 15 and 15 a, are highly magnified; but they are not uniformly enlarged; and, for the sake of clearness, they are rendered very slightly diagrammatic, though at the same time they are faithful representations of the objects drawn.]

- Fig. 1. Portion of a cross section of *Chatetes rhombicus*, Nich., showing part of the outer margin and part of the central area; 1 a, a few cells from the central portion of the same, still more highly magnified, showing the peculiar divisional lines in the calcite filling the tubes; 1 b, long section of part of a branch of the same.
- Fig. 2. Longitudinal section of part of a branch of *Chatetes sigillarioides*, Nich., showing the minutely tabulate interstitial tubuli.
- Fig. 3. Longitudinal section of part of a branch of *Chatetes nodulosus*, Nich.
- Fig. 4. Longitudinal section of part of a branch of *Chatetes rugosus*, Edw. & Haime.
- Fig. 5. Longitudinal section of part of a branch of *Chatetes Jamesi*, Nich.
- Fig. 6. Vertical section of part of a small example of *Chatetes petropolitanus*, Pander; 6 a, portion of a horizontal section of the same specimen.
- Fig. 7. Part of a horizontal section of *Chatetes discoideus*, James, close to the centre of the corallum; 7 a, portion of a vertical section of the same.
- Fig. 8. Part of a horizontal section of *Chatetes Newberryi*, Nich.; 8 a, part of a vertical section of the same.
- Fig. 9. Part of a horizontal section of *Chatetes clathratulus*, James; 9 a, part of a vertical section of the same. On one side a second layer of short corallites is seen to be superimposed on the two original layers forming the corallum.
- Fig. 10. Part of a transverse section of *Constellaria antheloidea*, Hall, showing a portion of the margin and a portion of the central region; 10 a, part of a vertical section of another example of the same.
- Fig. 11. Part of a horizontal section of *Chatetes frondosus*, D'Orb. (?); though essentially parallel to the surface, the section has divided the corallites in a slightly oblique manner; 11 a, part of a vertical section of another example of the same.
- Fig. 12. Part of a horizontal section of a branch of *Dekayia attrita*, Nich., taken from the central region of the branch, and showing the surface-columns cut across transversely; 12 a, part of a vertical section of another example of the same, showing the longitudinally divided columns as thickenings of the walls of the corallites.
- Fig. 13. Portion of a vertical section of a branch of *Chatetes gracilis*, James.
- Fig. 14. Portion of a transverse section of a branch of *Chatetes Fletcheri*, Edw. & Haime, showing part of the margin and part of the central area.
- Figs. 15 & 15 a. Transverse and vertical sections of *Streptelasma corniculum*, Hall.

(All the specimens figured are from the Cincinnati Group of Ohio, with the exception of the specimens of *C. petropolitanus* figured in 6 and 6 a, which are from the Trenton Limestone of Canada.)